



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) EP 0 936 742 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.08.1999 Bulletin 1999/33

(51) Int Cl.⁶ H03L 7/183

(21) Application number: 99300504.0

(22) Date of filing: 25.01.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(72) Inventors:
• Hoffman, Gilbert A.
Aloha, Oregon 97006 (US)
• Zink, Scott
Portland, Oregon 97229 (US)

(30) Priority: 01.02.1998 US 21699

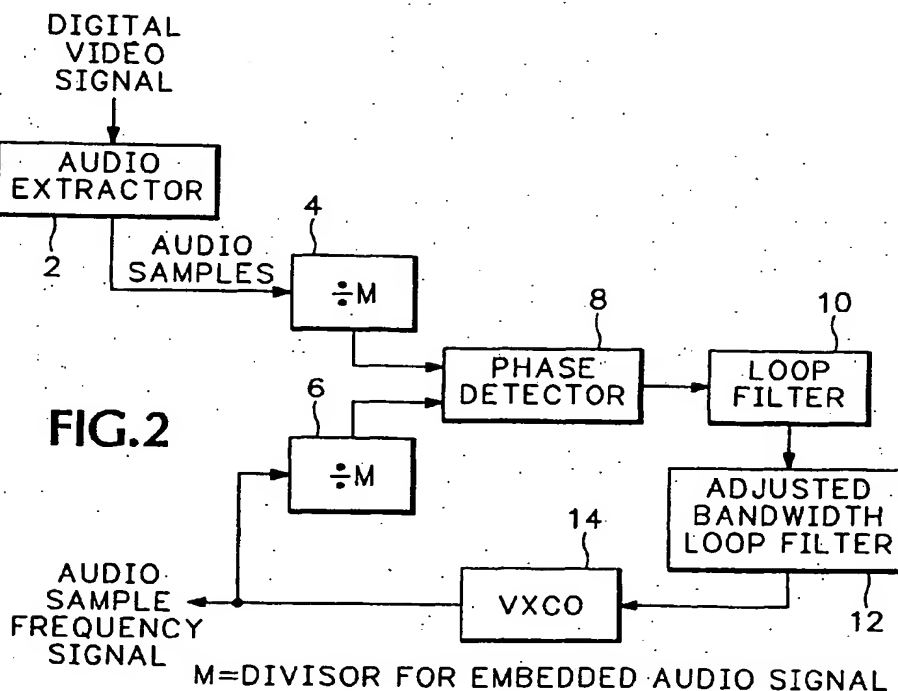
(74) Representative: Molyneux, Martyn William et al
Langner Parry
52-54 High Holborn
London WC1V 6RR (GB)

(71) Applicant: TEKTRONIX, INC.
Wilsonville, Oregon 97070-1000 (US)

(54) A system for phase-locking a clock to a digital audio signal embedded in a digital video signal

(57) A system for phase-locking a clock to a digital audio signal embedded within in a digital video signal uses an audio extractor, frequency dividers, and an adjusted bandwidth loop filter to prevent phase jitter associated with the digital audio signal preventing the functionality of the phase-lock loop or having unacceptable effects on the generated audio sample frequency signal.

Extracted audio samples are divided down and input to a phase detector. The signal is then filtered using a series of loop filters, one of which has an adjusted bandwidth to reject phase jitter. A clock then outputs the generated synthesized audio sample frequency using the output from the series of loop filters, and the synthesized frequency signal is looped back through a second frequency divider to the phase detector.



Description**Background of the Invention**

[0001] The present invention relates in general to digital video and audio, and more particularly to phase-locking a clock to a digital audio signal embedded within a digital video signal.

[0002] Audio data embedded within a digital video stream has a different integer frequency relationship to the video clock. For this reason, a conventional phase-locked loop locked to the video clock requires dividers for both the video clock signal and the synthesized audio clock signal as shown in Fig. 1. Depending upon the type of video signal, the audio signal's integer frequency relationship with the video clock may be relatively large. Conventionally, with some video signals, such as the National Television System Committee (NTSC) standard, the divider ratios become very large and impracticable to implement.

[0003] In the case of 14.31818 MHz NTSC D2 video, the integer ratio between the video clock and the 48 KHz audio clock is 4777500/16016. A conventional phase-locked loop that derives the 48 KHz audio signal in this case requires two dividers as shown in Fig. 1. One divides the video clock by 4777500, denoted by N in Fig. 1, and another which divides the audio clock by 16016, which is denoted by M Fig. 1. Also, in this case an additional problem is that the divided down frequency into the phase detector would be 2.997003 Hz, which requires a very slow loop filter.

[0004] Furthermore, accommodating a conventional multi-standard decoder requires switching divider ratios for each different video standard. For example, the divider ratio (M/N) described above for the NTSC D2 standard would change for both the Phase Alternate Line D2 (PAL D2) and 27 MHz D1 standards, which requires rather complex circuitry.

[0005] To avoid the above problems, another method to phase-lock a clock to an embedded digital audio signal is to detect each audio sample as it appears on the video and use that sample as an input to the phase detector of a phase-lock loop. This method is independent of the video standard, and works with a non-synchronous audio signal as well as with one synchronous to a video signal. However, significant problems with the above method exist. It happens that the audio data signal is "bursty" in that it has a great deal of phase jitter because the audio samples are dispersed very unevenly through the video signal. The phase jitter on the audio samples can be transferred to the regenerated audio clock created by the phase-lock loop and at times cause the phase detector to lose or gain cycles and not to function.

[0006] What is desired is a system for phase-locking a clock to a digital audio signal embedded within a digital video signal where phase jitter associated with the digital audio signal does not prevent the functionality

of the phase-lock loop or have unacceptable effects on the generated audio clock signal.

Summary of the Invention

[0007] In accordance with the illustrated preferred embodiment of the invention, a method and apparatus is disclosed to phase-lock a clock to a digital audio signal embedded within a digital video signal.

[0008] Audio samples are extracted from a digital video signal and are input to a frequency divider so that phase jitter present in the audio signal can be managed. The resultant signal is then processed by a phase detector, a first low pass input filter, and then a second loop filter in series with the first and configured in such a way to reject phase jitter. The output of the second loop filter is input to a voltage controlled oscillator (VCO) which includes its own frequency divider to divide down the clock signal to the original audio sampling frequency. The output of the VCO is then the resultant phase-locked audio sample frequency signal. This signal is input to a second frequency divider with the same divisor value as the frequency divider used to divide down the original input audio sample, before being looped back and input to the phase detector.

[0009] The objects, advantages, and other novel features of the present invention are apparent from the following detailed description when read in conjunction with the appended claims and attached drawing.

Brief Description of the Drawing

[0010] Fig. 1 is a block diagrammatic view of a prior art system for phase locking a clock to an audio signal embedded in a digital video signal.

[0011] Fig. 2 is a block diagrammatic view of a system for phase-locking a clock to a digital audio signal embedded in a digital video signal according to the present invention.

[0012] Fig. 3 is a block diagrammatic view of a voltage controlled oscillator (VCO) containing a frequency divider, according to the present invention.

Description of the Preferred Embodiment

[0013] Referring now to Fig. 2, a video signal is input to an audio extractor 2, the output audio samples from the audio extractor 2 are input to a first frequency divider 4. The divisor value of the first frequency divider 4 is that which will divide the frequency of the audio signal down enough so that the period is greater or equal to that of phase jitter present in the audio sample. This reduces phase jitter enough for a phase detector 8 to function. For example, if there is 1.0 ms of phase jitter present in an original 48 KHz extracted audio signal, the period of the original 48 KHz extracted audio signal will be smaller than the 1 ms of jitter. However, if the divisor of the frequency divider is 64, then the original 48 KHz extracted

audio signal will be divided down to a 750 HZ signal, with a period larger than the phase shift caused by the 1 ms phase jitter.

[0014] - The resultant signal from the first frequency divider 4 is then input to the phase detector 8. The output from the phase detector 8 is input to a first standard loop filter 10. The output of the loop filter 10 is then input to a second loop filter 12 with adjusted bandwidth in order to reject phase jitter. For example, the adjusted bandwidth second loop filter 12 may be a 10 Hz four-pole filter according to one preferred embodiment, which is sufficient to reject 50 Hz jitter, which is characteristic for embedded audio signals, but also may be configured to a degree that is sufficient to attenuate the phase jitter present in any specific original audio sample. However, the same effect is obtained by using a single loop filter. The single loop filter must be one that allows for a system gain to gradually decline to less than 1 with a phase shift not supporting oscillations at a gain of 1. The jitter frequency is higher than the crossover frequency at which the gain equals 1. Therefore, the single filter must have a bandwidth configured to a degree that is sufficient to attenuate the phase jitter present in the specific original audio sample.

[0015] The output of the second adjusted bandwidth loop filter 12 is then input to a voltage controlled oscillator (VCO) 14. Referring to Fig. 3, the VCO 14 contains an extra frequency divider 18, to divide down the output clock signal in this case to match the frequency of the embedded audio sample. Referring now to Fig. 2 again, the output from the VCO 14 is the synthesized audio sample frequency signal output with reduced phase jitter. The audio sample frequency signal is also input to a second frequency divider 6 with the same divisor as the first frequency divider 4. The divisors of the two frequency dividers 4, 6 are the same because the audio signal is extracted from the video signal and there is no need for a different divisor for phase-locking to the video signal clock.

[0016] The divided down audio sample frequency output from the second frequency divider 6 is then looped back and input to the phase detector 8 for comparison with the reference signal output from the first frequency divider 4.

[0017] Thus, the present invention provides a system for phase-locking a clock to a digital audio signal embedded within in a digital video signal where phase jitter associated with the digital audio signal does not prevent the functionality of the phase-locked loop or have unacceptable effects on the generated audio clock signal.

Claims

1. A method for phase-locking a clock to a digital audio signal embedded within in a digital video signal comprising the steps of:

generating a first reference frequency signal from a digital audio signal sample embedded within a digital video signal;
generating a second reference frequency signal from an output audio sample frequency signal;
generating from the first and second reference frequencies a low jitter clock control signal; and
generating the output audio sample frequency signal from the low jitter clock control signal.

2. The method according to claim 1, wherein the first reference frequency generating step comprises the steps of:

extracting an embedded audio signal from a digital video signal; and
dividing down the extracted audio signal such that a divided down frequency is produced that has a period greater or equal to that of phase jitter present in the extracted audio sample.

3. The method according to claim 2, wherein the second reference frequency generating step comprises the steps of:

dividing down the output audio sample frequency signal with a divisor equal to that used to divide the extracted audio signal; and
outputting the divided down audio sample frequency signal.

4. The method according to claim 1, wherein the low jitter clock control signal generating step comprises the steps of:

inputting the first and second reference frequency signals into a phase detector; and
filtering output from the phase detector such that the phase jitter present in the audio sample signal is rejected and a low jitter clock control signal is produced.

5. The method according to claim 4, wherein the filtering step comprises the step of inputting output from the phase detector through a series of two loop filters, one of which is an adjusted bandwidth loop filter, such loop filter's bandwidth configured to a degree which is sufficient to attenuate the phase jitter that is present in the embedded audio signal, such that a low jitter clock control signal is produced.

6. The method according to claim 4, wherein the filtering step comprises the step of inputting output from the phase detector to a loop filter, such loop filter allowing for a system gain to decline to less than 1 with a phase shift not supporting oscillations at a gain of 1, and such loop filter's bandwidth is config-

ured to a degree which is sufficient to attenuate the phase jitter that is present in the embedded audio signal, such that a low jitter clock control signal is produced.

7. The method according to claim 1, wherein the output audio sample frequency signal generating step comprises the steps of:

inputting the low jitter clock control signal to a VCO;
dividing down an initial output of the VCO to the frequency of the original embedded audio sample signal; and
outputting the divided down signal as the output audio sample frequency signal.

8. An apparatus for phase-locking a clock to a digital audio signal embedded within in a digital video signal comprising:

means for generating a first reference frequency signal from a digital audio signal sample embedded within a digital video signal;
means for generating a second reference frequency signal from an output audio sample frequency signal;
means for generating from the first and second reference frequencies a low jitter clock control signal; and
means for generating the output audio sample frequency signal from the low jitter clock control signal.

9. The apparatus of claim 8, wherein the first reference frequency generating means comprises:

means for extracting an embedded audio signal from a digital video signal; and
means for dividing down the extracted audio signal such that a divided down frequency is produced that has a period greater or equal to that of phase jitter present in the extracted audio sample.

10. The apparatus of claim 9, wherein the second reference frequency generating means comprises:

means for dividing down the output audio sample frequency signal with a divisor equal to that used to divide the extracted audio signal; and
means for outputting the divided down audio sample frequency signal.

11. The apparatus of claim 8, wherein the low jitter clock control signal generating means comprises:

means for inputting the first and second refer-

ence frequency signals into a phase detector; and

means for filtering output from the phase detector such that the phase jitter present in the audio sample signal is rejected and a low jitter clock control signal is produced.

12. The apparatus of claim 11, wherein the filtering means comprises means for inputting output from the phase detector through a series of two loop filters, one of which is an adjusted bandwidth loop filter, such loop filter's bandwidth configured to a degree which is sufficient to attenuate the phase jitter that is present in the embedded audio signal, such that a low jitter clock control signal is produced.

13. The apparatus of claim 11, wherein the filtering means comprises means for inputting output from the phase detector to a loop filter, such loop filter allowing for a system gain to decline to less than 1 with a phase shift not supporting oscillations at a gain of 1, and such loop filter's bandwidth is configured to a degree which is sufficient to attenuate the phase jitter that is present in the embedded audio signal, such that a low jitter clock control signal is produced.

14. The apparatus of claim 8, wherein the output audio sample frequency signal generating means comprises:

means for inputting the low jitter clock control signal to a VCO; and
means for dividing down an initial output of the VCO to the frequency of the original embedded audio sample signal; and
means for outputting the divided down signal as the output audio sample frequency signal.

15. A system for phase-locking a clock to a digital audio signal embedded within in a digital video signal comprising:

an audio extractor, operative for extracting an embedded audio signal from a digital video signal;

a first frequency divider coupled to the audio extractor, operative for dividing down an extracted audio signal, having a divisor such that the divided down signal has a period greater or equal to that of phase jitter present in the extracted audio sample;

a phase detector coupled to the first frequency divider;

a loop filtering apparatus coupled to the phase detector, such that the phase jitter present in the extracted audio signal is rejected and a low jitter clock control signal is produced;

a VCO coupled to the loop filter apparatus; and
a second frequency divider with input coupled
to the VCO and output coupled to the phase de-
tector, such frequency divider having a divisor
equal to that of the first frequency divider.

5

16. The system according to claim 15, wherein the loop
filtering apparatus comprises:

a first loop filter coupled to the phase detector; 10
and
a second loop filter coupled to the first loop fil-
ter, one of which is an adjusted bandwidth loop
filter, such loop filter's bandwidth configured to
a degree which is sufficient to attenuate the 15
phase jitter that is present in the embedded au-
dio signal, such that a low jitter clock control sig-
nal is produced.

17. The system according to claim 15, wherein the loop 20
filtering apparatus comprises a loop filter coupled
to the phase detector, such loop filter allowing for a
system gain to decline to less than 1 with a phase
shift not supporting oscillations at a gain of 1, and 25
the loop filter's bandwidth is configured to a degree
which is sufficient to attenuate the phase jitter that
is present in the embedded audio signal, such that
a low jitter clock control signal is produced.

18. The system according to claim 15, wherein the VCO 30
comprises:

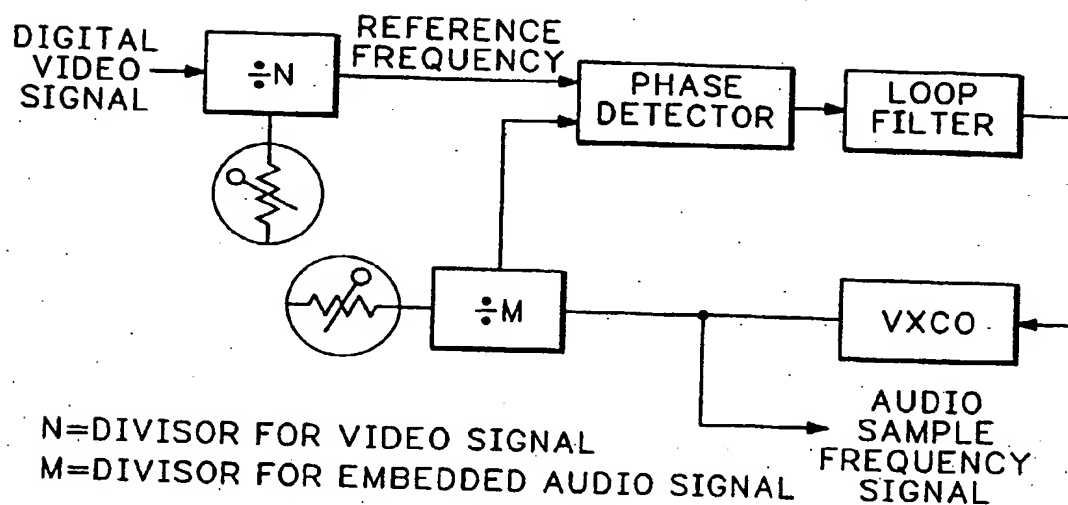
means for generating a clock signal from a low
jitter clock control signal coupled to the loop fil-
tering apparatus; and 35
a frequency divider coupled to the clock signal
generating means, such frequency divider hav-
ing a divisor that divides the audio clock signal
down to the frequency of the extracted audio 40
signal.

40

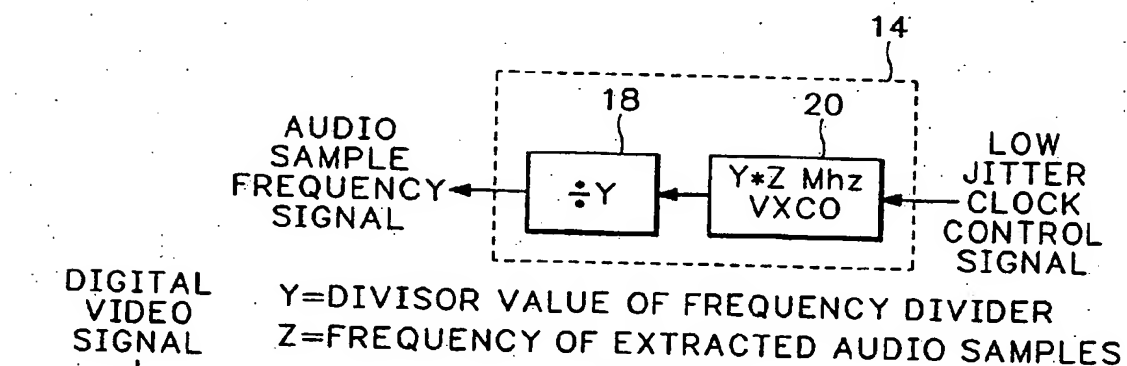
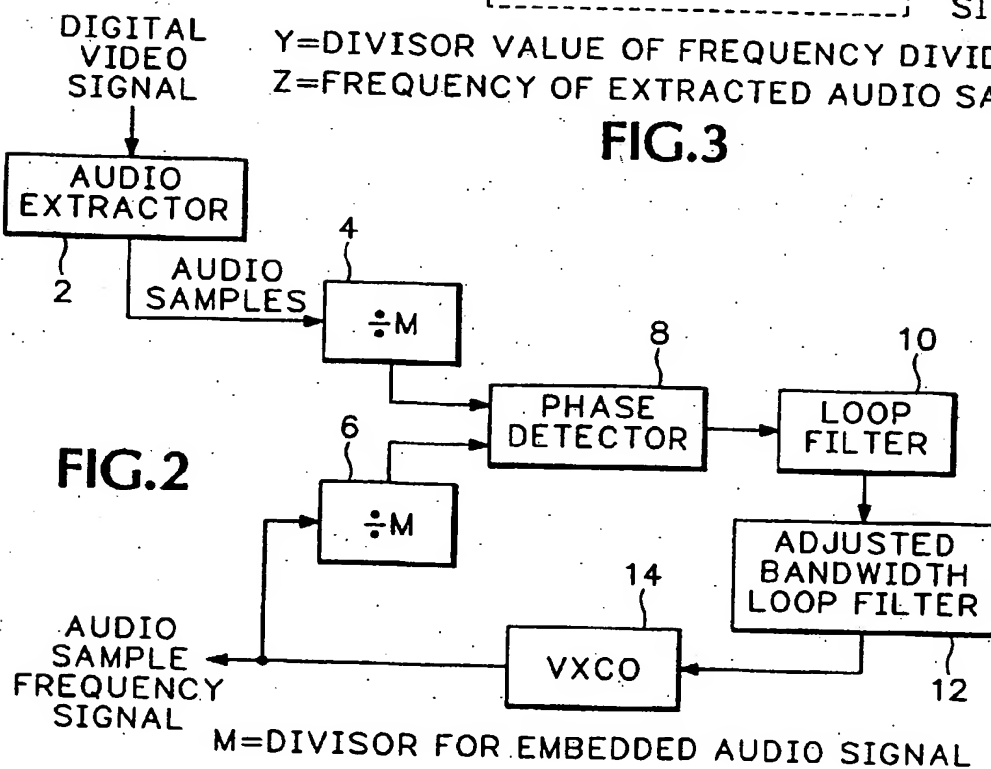
45

50

55

**FIG.1**

(PRIOR ART)

**FIG.3****FIG.2**



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 0504

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 703 537 A (BLAND CHRISTOPHER J ET AL) 30 December 1997 * the whole document *	1,2,4,6,8,9,11	H03L7/183
X	EP 0 395 347 A (MATSUSHITA ELECTRIC IND CO LTD) 31 October 1990 * column 5, line 25 - column 8, line 38 *	1,8	
Y	US 5 506 627 A (CIARDI JOHN J) 9 April 1996 * the whole document *	1-18	
Y	US 5 602 882 A (CO RAMON S ET AL) 11 February 1997 * column 1, line 53 - column 5, line 25 *	1-18	
Y	US 5 162 746 A (GHOSHAL SAJOL C) 10 November 1992 * column 4, line 39 - column 5, line 4 *	1-18	
Y	US 5 276 712 A (PEARSON JONATHAN D) 4 January 1994 * abstract *	1-18	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H03L
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 20 May 1999	Examiner Kahn, K-D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO Form 1503 03/92 (Pct-03)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 30 0504

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-05-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5703537 A	30-12-1997	NONE	
EP 0395347 A	31-10-1990	JP 2116880 C	06-12-1996
		JP 2287974 A	28-11-1990
		JP 8034039 B	29-03-1996
		JP 3153138 A	01-07-1991
		DE 69015421 D	09-02-1995
		DE 69015421 T	10-08-1995
		US 5142420 A	25-08-1992
US 5506627 A	09-04-1996	NONE	
US 5602882 A	11-02-1997	US 5502750 A	26-03-1996
US 5162746 A	10-11-1992	US 5077529 A	31-12-1991
US 5276712 A	04-01-1994	AU 6896191 A	13-06-1991
		CA 2045166 A	17-05-1991
		EP 0453557 A	30-10-1991
		JP 4505239 T	10-09-1992
		WO 9107832 A	30-05-1991

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82